09/445892

420 Rec'd PCT/PTO 14 DEC 1999

METHOD FOR MANUFACTURING A MULTI-LAYERED CERAMIC SUBSTRATE

FIELD OF THE INVENTION

The present invention relates to the field of methods for manufacturing a multi-layered ceramic substrate used for electronic devices, and in particular to methods for manufacturing a so-called non-shrinkable multi-layered substrate which greatly suppresses shrinkage of the substrate during firing.

BACKGROUND OF THE INVENTION

Normally, multi-layered ceramic substrates are manufactured using a method called the green sheet lamination method. In this method, green sheets, made by forming a slurry containing ceramic powder and organic binder into a sheet, are punched (for holes) and screen printed with conductive paste. These green sheets are stacked to the required number, press-heated to laminate the layers, and then fired.

The advantages of this method include the feasibility of fine pattern printing realized by the extremely flexible green sheet and good permeability to organic solvents; and good surface smoothness and air-tightness which allow the lamination of even up to several dozens of layers.

On the other hand, the main disadvantage is the difficulty in achieving dimensional accuracy. This is due to shrinkage of the ceramic substrate accompanied by sintering which occurs during firing it. Inaccurate dimensions cause mismatching between components and conductive patterns, generating the serious problem of inability to mount semiconductor chips such as CSPs (chip size packages) and MCMs (multi-chip modules) with high accuracy.

As a result, recent developments have been focusing on a method for eliminating lateral shrinkage during firing. This method involves the formation of shrinkage suppression sheets, using the doctor blade method, containing a ceramic material such as alumina which does not sinter at the sintering temperature of green sheet. These sheets are disposed on both faces of the green sheet laminated body and fired. The sintered multi-layered ceramic substrate then shrinks only in the thickness direction and not in the lateral direction, enabling semiconductor chips to be mounted with much higher accuracy.

Fig. 2 shows the conventional method for manufacturing a multi-layered ceramic substrate 2. After firing the multi-layered ceramic substrate 2, shrinkage suppression sheets 1 on both faces of a multi-layered ceramic substrate are removed by rotating a dry rotary brush 3 at high speed, as illustrated in Fig. 2.

However, this conventional removal method may not be able to accurately control amount of shrinkage suppression sheet to be removed by simply changing the rotation speed of the rotary brush or the distance to the substrate, i.e., the strength of the brush polishing the substrate. For example, too slow brush rotation speed or insufficient polishing time causes uneven removal. The conductive pattern on the surface of the multi-layered substrate may be damaged if the revolution of the brush is too fast or polishing time is too long. As a result, the conductive pattern may be disconnected or short-circuited, resulting in a low yield rate. Furthermore, in the case of an irregularly-shaped substrate with a cavity A on the surface of the multi-layered substrate, as shown in Fig. 2, residue in the cavity A is not always successfully removed by the rotary brush 3.

SUMMARY OF THE INVENTION

A method for manufacturing a multi-layered ceramic substrate of the present invention involves spraying of water, ceramic powder, or a mixture of ceramic powder and water together with compressed air for removing a shrinkage suppression sheet from a green sheet laminated body contained low-temperature firing substrate material.

The fine controllability of this method by changing the pressure of compressed air enables to remove the shrinkage suppression sheet completely without causing uneven removal even if a cavity exists in the substrate. In addition, its polishing capability improves by adding ceramic powder.

Furthermore, conditions of ceramic powder remain unchanged even removed shrinkage suppression sheet material mixes with ceramic powder because the same material is used for ceramic powder to be sprayed and main constituent of the shrinkage suppression sheet. Accordingly, sprayed ceramic powder can be collected for reuse in spraying, enabling this method to be applied to circulating continuous devices.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view depicting a method for manufacturing a multi-layered ceramic substrate in accordance with an exemplary embodiment of the present invention.

Fig. 2 is a side view depicting a method for manufacturing a multi-layered ceramic substrate of the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An exemplary embodiment of the present invention is described with reference to Fig. 1. A green sheet laminated body 2 is an unfired multi-layered

low-temperature firing substrate, before sintering, made typically of alumina and glass. Shrinkage suppression sheets 1 formed by the doctor blade method are disposed on both faces of the green sheet laminated body 2. A material which does not sinter at the sintering temperature of the green sheet laminated body 2 is selected for the shrinkage suppression sheet 1. Typically, the shrinkage suppression sheet 1 is made of a ceramic material such as alumina. Then, the green sheet laminated body 2, on which the shrinkage suppression sheets 1 are formed on both faces, is fired.

After firing, the shrinkage suppression sheets 1 formed on both faces of the green sheet laminated body 2 are removed by spraying a mixture of water and alumina powder from a nozzle 4 connected to a feeding pipe for supplying water and alumina powder mixture 5 and a feeding pipe for supplying compressed air 6. The shrinkage suppression sheets 1 are thus removed by the injection pressure of water and alumina powder mixture.

Conditions for removing the shrinkage suppression sheet were studied, and two examples are described below. In the examples, a multi-layered ceramic substrate 2 of 115 mm x 115 mm and a 200 μm thick shrinkage suppression sheet 1 made of alumina are used.

(EXAMPLE 1)

Table 1 shows the process conditions and the satisfactory results obtained by mixing 96 g of water and 4 g of alumina powder with a mean particle size of 0 to 10 μm, and spraying the mixture for about 100 to 400 seconds using compressed air at a pressure of 3.0 to 5.5 kg/cm^2.

(EXAMPLE 2)

Table 2 shows process conditions and the satisfactory results obtained by using only alumina powder with a mean particle size of 0.1 to 150 μm without

using water, and spraying alumina powder for about 100 to 400 seconds using compressed air at a pressure of 3.0 to 5.5 kg/cm^2.

In these examples, the distance between the multi-layered ceramic substrate 2 and nozzle 4 was about 50 mm. After removal, the substrate was rinsed with deionized water at 120 ± 5 °C for 15 minutes. Tables 1 and 2 also show a comparison of the results of the conventional manufacturing method and that of the present invention.

Table 1

	EXAMPLE 1 (using water)						prior art
pressure (Kg/cm^2)	5.3	3.5	3.5	3.5	3.5	3.5	brush
use of water	yes	yes	yes	yes	yes	yes	no
particle size(μm)	0	0.5	1.0	2.5	5.0	10	-
removal time (sec)	400	300	200	150	100	100	500
uneven removal	no	no	no	no	no	no	yes
Damage to substrate	no	no	no	no	no	no	scratches by brush
irregularly-shaped substrate	easy	easy	easy	easy	easy	easy	difficult

Table 2

	EXAMPLE 2 (without using water)				
pressure (Kg/cm^2)	3.5	3.5	3.5	3.5	2.5
use of water	no	no	no	no	no
particle size(μm)	0.1	10	50	100	150
removal time (sec)	400	250	200	100	100
uneven removal	no	no	no	no	no
Damage to substrate	no	no	no	no	no
irregularly-shaped substrate	easy	easy	easy	easy	easy

In this exemplary embodiment, the green sheet laminated body 2 contains alumina, and the shrinkage suppression sheet 1 contains alumina powder.

Accordingly, impurities do not react with the conductive paste and cause a detrimental effects on the laminated body when firing the green sheet laminated body 2 after printing resistance and the like in the process after removing the shrinkage suppression sheet 1. This is due to the use of inorganic alumina powder, which is of the same constituent as the shrinkage suppression sheet, for ceramic powder. Since the conventional method removes the shrinkage suppression sheet 1 by means of a rapidly rotating brush, burning may occur on the surface of the green sheet laminated body 2 by organic substance in the brush, depending on the material of the brush. The remaining organic substance may cause detrimental effects to the laminated body when firing the green sheet laminated body 2 after removing the shrinkage suppression sheet 1.

If the mean particle size of ceramic powder for removing the shrinkage suppression sheet 1 exceeds the range shown in the above examples, cracks may occur on the surface of the ceramic substrate. If the pressure of the compressed air exceeds the above range, it may take too much time for removing the shrinkage suppression sheet 1, or cause cracks on the substrate surface or breakage of the substrate.

The shrinkage suppression sheet is also removable by spraying just water without ceramic powder, combined with compressed air.

Industrial applicability

In the manufacture of a multi-layered ceramic substrate by forming shrinkage suppression sheets on both faces of unfired laminated green sheets, firing the laminated green sheets, and removing the shrinkage suppression sheets; the present invention enables to prevent uneven removal or damage to the conductive pattern which occurs in the conventional method, and reduce operation time. Even

for irregularly-shaped multi-layered substrate with cavities on its surface, the shrinkage suppression sheet may be removed completely. Polishing strength is finely controllable by adjusting the mixing ratio of spraying liquid, air pressure, time, and nozzle distance. In addition, the operation can be executed on both faces simultaneously by clamping the substrate.

Accordingly, shrinkage of the substrate during firing is suppressed to an extremely high degree, and so-called non-shrinkable multi-layered substrate can be reliably manufactured. This enables to mount components on multi-layered substrates without any mismatching between components and their respective conductive patterns, and also mount semiconductor chips such as CSPs (chip size packages) and MCMs (multi-chip modules) with high accuracy, making high density mounting feasible.

Furthermore, the use of same material for ceramic powder to be sprayed and main constituent of shrinkage suppression sheet allows to collect sprayed ceramic powder for reuse in spraying, enabling this method to be applied to circulating continuous devices.